NASA Johnson Space Center Small Business Innovation Research (SBIR) Successes, Infusions and Commercializations and Potential International Partnering Opportunities

Kathryn Packard[1],
NASA Johnson Space Center, Houston Texas, 77058

and

Doug Goodman[2] and James Whittington[3]
Jacobs Technology, Houston, TX 77598

The NASA Small Business Innovation Research (SBIR) Program has served as a beneficial funding vehicle to both US small technology businesses and the Federal Agencies that participate in the program. This paper, to the extent possible, while observing Intellectual Property (IP) laws, will discuss the many SBIR and STTR (SBIR Technology Transfer) successes in the recent history of the NASA Johnson Space Center (JSC). Many of the participants of the International Conference on Environmental Systems (ICES) have based their research and papers on technologies that were made possible by SBIR/STTR awards and post award funding. Many SBIR/STTR successes have flown on Space Shuttle missions, Space X Dragons, and other spacecraft. SBIR/STTR technologies are currently infused on the International Space Station (ISS) and satellites, one of which was a NASA/JAXA (Japanese Space Agency) joint venture. Many of these companies have commercialized their technologies and grown as businesses while helping the economy through the creation of new jobs. In addition, this paper will explore the opportunity for international partnership with US SBIR/STTR companies as up to 49% of the makeup of the company is not required to be American owned. Although this paper will deal with technical achievements, it does not purport to be technical in nature. It will address the many requests for information on successes and opportunities within NASA SBIR and the virtually untapped potential of international partnering.

Nomenclature

ACT2 = Analytical Containment Transfer Tool
ARMD = Aeronautics Research Mission Directorate
CASIS = Center for the Advancement of Science in Space
COR = Contracting Officer Representative
DAA = *Document Availability Authorization*

[1] SBIR Technology Infusion Manager, Strategic Partnerships Office (XP), Johnson Space Center, 2101 NASA Parkway, Houston, TX 77058
[2] SBIR technical writer, Jacobs Technology, 2222 Bay Area Blvd., Houston, TX 77058
[3] SBIR coordinator, Jacobs Technology, 2222 Bay Area Blvd., Houston, TX 77058

EHB = *Electronic Handbook*
FAR = *Federal Acquisitions Regulations*
GPM = *Global Precision* Measurement
HEOMD = Human Exploration and Operations Mission Directorate
HQ = Headquarters
ICES = International Conference on Environmental Systems
IP = *Intellectual Property*
ISS = *International Space Station*
JAXA = *Japanese Aerospace Agency*
JSC = *Johnson Space Center*
MGM = *Multi-Gas Monitor*
OLGA = *Optical Life Gas Analyzer*
POC = Point of Contact
R&D = Research and Development
SBC = Small Business Concern
SBIR = Small Business Innovation Research
SMD = Science Mission Directorate
SSP = Space Shuttle Program
STI = *Scientific and Technical Information*
STMD = Space Technology Mission Directorate
STTR = Small Business Technology Transfer
TIM = Technology Infusion Manager
TPOC = Technical Point of Contact

I. Introduction

This paper will highlight recent successes from JSC Small Business Innovation Research (SBIR) and SBIR Technology Transfer (STTR) technologies and will discuss opportunities and limitations of foreign partnerships. The goal is to increase participation and partnering within the small business community by providing examples of strong, successful SBIR and STTR technologies to attendees of the 2016 ICES conference.

II. Background of SBIR/STTR Program

The SBIR program was established in 1982 under the Small Business Innovation Development Act "to strengthen the role of innovative small business concerns (SBCs) in Federally –funded research and development (R/R&D)".[1]

The Act has been extended through September 30, 2017 and requires any Federal Agency with an R&D budget over $100,000,000 to participate in the Program and award at least 3.2% of this budget to small businesses for FY 2016.

Four NASA Mission Directorates participate in the NASA SBIR Program. They are Human Exploration and Operations Mission Directorate (HEOMD), Science Mission Directorate (SMD), Aeronautics Research Mission Directorate (ARMD) and Space Technology Mission Directorate (STMD), each with their own technology portfolio. The program resides at NASA Headquarters (HQ) in Washington DC and at Ames Research Center (ARC) with one Technology Infusion Manager (TIM) serving as the Point of Contact (POC) for each center.

A. Four Goals of the SBIR Program[2]

1. Stimulate technological innovation.
2. Meet Federal research and development needs.
3. Foster and encourage participation in innovation and entrepreneurship by socially and economically disadvantaged persons.
4. Increase private-sector commercialization of innovations derived from Federal research and development funding.

B. Eligibility

To be eligible to participate in the SBIR Program, the proposing small business must be for-profit, at least 51% American owned and independently operated, and located in the United States with the principal investigator's primary employment with the small business during the project. The small business must consist of 500 or fewer employees.

C. Solicitations

Each Federal Agency holds a separate solicitation each year. Per each agency's discretion, the solicitations may be held at any time during the year and the time may differ from year to year as well.

III. Success Story Process

Success stories are developed through a NASA database that SBIR partners can access. Through the database (the Electronic Handbook (EHB)), the SBCs may submit a success opportunity. (Sometimes the agency discovers the success outside of the system. In these cases, the successes are uploaded into the system and then verified with the SBC.) After the JSC SBIR team is made aware of the success, JSC reaches out to the JSC Contracting Representative (COR) or Technical Point of Contact (TPOC) for the technology as well as the SBC's POC. The information is used to develop a success opportunity sheet that is then presented to the agency SBIR program. Areas of emphasis in the success opportunity include:

A. Importance of the Innovation

This answers the question of why the innovation is being raised as a success opportunity. A good piece of information to include is what is different at NASA now that the technology is in place. For example, a piece of hardware may allow research capability that did not exist once NASA moved away from the Space Shuttle Program (SSP).

B. Company Deliverable

Any materials, reviews, hardware, or software, etc. that the company created as part of the SBIR.

C. End Product Infusion

Did the technology fly? Is it being actively used at JSC?

D. Non-NASA Partner Contribution

For some levels of SBIR participation, matching donations are required from another source, such as the ISS National Lab or the Department of the Navy.

E. Other Government Applications

Some technologies are created solely for NASA, but others are built with multiple Government agency applications.

F. Commercial Applications

Has the technology been sold or licensed, and did the company hire people as a result of the technology's commercialization? Because this kind of information is sensitive and proprietary to comapnies, many companies are hesitant to provide commercialization information.

Based on the presentation to the Agency, the NASA SBIR program selects which success opportunities to develop into success stories. At this point, a story is generated by the NASA SBIR program and reviewed at the center level and by the SBC. Once the story is finalized, it is reviewed for STI and can be released to the public. However, since 2014 (and as of the date of the submittal of this paper), the Agency has not released success stories to the public. (The examples provided in Section VI are either being processed or written.)

Recently, the program replaced success opportunity sheets with technology (tech) sheets. The purpose of the tech sheet is to streamline the chart while emphasizing the technical information from the success. The areas emphasized in the tech sheet are:

A. Challenges

What are the technological challenges presented in the development of the technology? Were there specific requirements, or did the technology have to undergo unique testing? The success opportunity's Importance of the Innovation can map to here.

B. Objectives

What were the goals in developing the technology? What was the process, and what was the outcome?

C. Impacts

This section replaces the Commercial Applications, Government Applications, and Company Deliverables. The section allows for each one to be highlighted and numbered to bring singular achievement to the impact.

The tech sheets follow a similar process as success opportunities except that process steps have been added to assist with IP. Firm release and STI approval are required to finalize the tech sheet. If the SBC does not release the information, the tech sheet is still made available in the EHB for NASA but not for public dissemination.

IV. Challenges to Communicating Successes

Although NASA may use and infuse the technology developed via an SBIR/STTR award, the company will own the resulting Intellectual Property (IP), data, copyrights, patents, etc. Because of the strict IP rights afforded the company, it is not always easy for the government to discuss the numerous and varied successes that these small business have afforded NASA over the years. This creates a vacuum where technology is advanced and commercialized but not publicized, which may lead to the idea that NASA is not developing as many technologies as expected. It is important to note, however, that this lack of publicizing is done for the sake of the small business. IP is the biggest challenge to communicating SBIR/STTR successes.

The Federal Acquisitions Regulations (FAR) 52.227-20[3] governs the rights of data first produced in a Federally-funded SBIR contract. The FAR prevents the Government from releasing data outside of the Government without permission of the SBC for 4 years after the delivery of the last deliverable under the agreement. Even after 4 years, many Centers are hesitant to publish technological information because of the fear of publishing IP or giving away the "secret sauce."

Before release, JSC-authored Scientific and Technical Information (STI) is reviewed and approved by technical reviewers, monitors, export control, the Directorate of origin, the Tech Transfer Office, and Publications to ensure conformance to NASA policy and Federal regulations/laws[4]. JSC uses the Document Availability Authorization (DAA), a system that facilitates the approval process for external release of STI and allows users to track the progress of the approval process. STI is the results of basic and applied research and development, regardless of media or format. All NASA STI must be approved prior to release outside of JSC or to internal audiences that may include foreign nationals.

Finally, even when NASA systems and processes allow for the public dissemination of materials, sometimes the SBC does not want their success disseminated publicly. Per their request, the information is withheld from public release.

V. Types of Successes

The SBIR Program measures successes along several categories, and each of the success stories presented will fall into one of the categories. Successes can be sorted as Technology, Commercial, and Flight.

Flight successes apply to technologies that have flown in a NASA mission. They can have flown aboard a space shuttle, or they could have been transported by Soyuz, Dragon, or other commercial crew transport to ISS.

Technology successes are reported when the hardware/software was fully realized as a Phase 2e, Phase 3, or Commercial Readiness Program technology. They do not necessarily need to fly on-orbit to be technological successes. For example, a technology could be developed to assist with astronaut training or selection and not fly.

Commercial successes are reported by the SBC to NASA. This information includes number of sales, dollar amounts, or number of personnel hired due to successful commercial enterprising.

VI. Technological Successes

The following examples are successes in the queue for potentially being developed into success stories. They have been reviewed for accordance with IP laws. Information that conflicts with a company's rights has been withheld.

A. Techshot Bone Densitometer

The bone densitometer is an example of a Flight hardware success. It is the first X-ray machine in the space station. The bone densitometer launched on SpaceX-4 to the ISS on September 21, 2014.

The effects of microgravity on body tissue is one of the primary challenges of long-duration spaceflight. Of particular concern is the effect of microgravity on bone density. It is estimated that astronauts can lose between one and two percent of their total bone mass for every consecutive month spent in a microgravity environment.

Techshot developed a bone densitometer that could accurately take bone densitometry x-rays of rodents while on-orbit. Because the hardware allows NASA to study bone density on-orbit (instead of pre- and post-flight), not only will processing time be vastly reduced, but also the accuracy of the studies will be increased.

Funding was provided from the Center for the Advancement of Science in Space (CASIS) and NASA ISS.

B. Techshot ACT2

Techshot has developed two technologies that are great examples of how different a technological success can be. While the bone densitometer combines hardware and software advances, the Analytical Containment Transfer Tool (ACT2) is purely hardware. The ACT2 is a disposable device that doubly-contains[5] samples in a commercially-available syringe. This allows astronauts to transfer fluids between experiment hardware and an analyzer and to remove samples from on-orbit processing hardware for storage and return to earth. Previously, these fluids would have been frozen and stored until they could be analyzed post-Flight. This device increases the functionality of the ISS as a laboratory. It is scheduled to fly to the ISS on a Dragon spacecraft currently slated for March 2016.

C. Advanced Cooling Technologies Heat Pipes Exchangers

The Advanced Cooling Technologies Heat Pipes Exchangers is an example of a Technological, Commercial, and Flight success. The Heat Pipes Exchangers were developed to increase the safety of the environmental control system by separating the two exchanger loops with heat pipes, thus reducing the risk of ammonia leaks and providing an advanced warning of leakage.

The technology was integrated into the Global Precision Measurement (GPM) satellite, a NASA/Japanes Aerospace Exploration Agency (JAXA) venture that launched in February 2014.

In addition, total sales for the heat exchangers have exceeded $3.8M. Nine commercial telecommunications satellites have launched with ACT's heat pipes installed in the thermal control systems.

D. Aurora Flight Sciences Corporation ISS Universal Battery Charging Station

All new rechargeable battery systems (batteries and chargers) intended for use on the ISS must undergo an extensive qualification process. Since most chargers are only capable of charging a few specific batteries, numerous, different chargers are needed to support the battery-operated equipment on ISS. This results in significant mass overhead and creates stowage issues. Replacing some of these systems with a single charging solution, and at the same time providing a universal platform for future battery-operated systems, significantly reduces up-mass and stowage requirements. Vista Photonics conducted a survey of ISS batteries, then built their adapters based on the survey. This includes batteries for power tools, camcorders, and EVA tools.

The ISS Universal Battery Charging Station is scheduled to launch on SpaceX-8 in February 2016. Among other equipment, it will be used to charge the popular SPHERES (Synchronized Position, Hold, Engage, Reorient, Experimental Satellites) units. Replacing the chargers will reduce the number of chargers, and simplify tasks for astronauts.

E. Vista Photonics Multi-Gas Monitor

With the extension of ISS to 2020, NASA wanted to improve its ability to monitor the ISS habitable environment. Vista Photonics, Inc. received an SBIR award to develop a single, portable gas analyzer that can detect multiple gases (i.e., oxygen, carbon dioxide, water vapor, and ammonia).

The MGM is the first laser sensor to continuously measure these gases on a spacecraft. Monitoring these gases is crucial for ensuring crewmembers' health aboard the ISS. Prior to the MGM, three separate devices were used to monitor these gases.

The MGM was launched on Soyuz 37 in November 2013. In February 2014, the MGM was activated. The device continues to operate well past its initial 6-month technology demonstration period. NASA is now expanding the technology's gas-monitoring capabilities for use in Orion.

On January 14, 2015, astronauts and cosmonauts onboard the ISS evacuated to the Russian side of the outpost after an ammonia leak was detected. The MGM, which detects ammonia, helped determine that the ammonia leak aboard the ISS was a false alarm.

VII. International Partnering Challenges

Although it is commonly known that according to the SBIR eligibility requirements, an SBIR/STTR award may only be given to an entity 51% American owned and that the work must be performed on American soil, there are exceptions.

According to the Small Business Administration Office of Investment and Innovation SBIR Program Policy Directive 6.(4)[6]: "For both Phase I and Phase II, the R/R&D work must be performed in the United States. However, based on a rare and unique circumstance, agencies may approve a particular portion of the R/ R&D work to be performed or obtained in a country outside of the United States, for example, if a supply or material or other item or project requirement is not available in the United States. The funding agreement officer must approve each such specific condition in writing." In fact, the NIH states on their SBIR/STTR website[7] that if "….the study design (e.g. patient population) is not available in the United States, NIH may allow a small portion of the research/R&D work to be performed by a foreign organization".

In addition, the US Small Business Administration Guide to SBIR/STTR Program Eligibility lays out very succinctly the rules for participation for combinations of certain types of eligible entities (individuals and/or other firms) as well as how ownership is determined. Table 1 below (originally published in the Guide to SBIR/STTR Program Eligibility[8]) lays out nine examples of various combinations of partnerships that would allow or preclude eligibility in the SBIR/STTR Program.

Table 1. Illustrative examples of SBIR/STTR Ownership Options

OWNERSHIP SHARES (% of stock) Circles identify the majority ownership block that meets the eligibility criteria						
Ex.	*Individual(s)[a]*	*SB1[b]*	*SB2[b]*	*VC1[c]*	*VC2[c]*	*Other: e.g., large co., univ, non-profit*
Standard program (agencies not using Sec. 5107 authority)						
1	60	30				10
2	20	20	20	20		20
3		40	20	20		20
4	40			60		
5	20			40	30	10
For those agencies using Sec. 5107 authority						
6				50	50	
7		49		31	20	
8	10			60	30	
9	30	10	10	20	20	10

[a] Individual(s) who are citizens of or permanent resident aliens in the US.

[b] A small business (other than the awardee) that is directly owned and controlled by one or more individuals who are citizens or permanent resident aliens of the US.

[c] Firms specified in Sec. 5107, specifically: a venture capital operating company (VCOC), hedge fund, or private equity firm.

Explanation of examples in Table 1:

Example 1: The firm is eligible because it is more than 50% owned by one or more individuals who are US citizens or permanent resident aliens.

Example 2: The firm is eligible because it is more than 50% owned by a combination of *citizens of or permanent resident aliens in the US* and other small businesses owned by *citizens of or permanent resident aliens in the US*.

Example 3: The firm is eligible because it is more than 50% owned by a combination of other small businesses owned by *citizens of or permanent resident aliens in the US*.

Example 4: The firm is not eligible because it is not majority owned by *citizens of or permanent resident aliens in the US or other small businesses owned by citizens of or permanent resident aliens in the US.* Like example 9, this firm would also not be eligible for an award from an agency using section 5107 authority.

Example 5: The firm is not eligible because it is not majority owned by *citizens of or permanent resident aliens in the US or other small businesses owned by citizens of or permanent resident aliens in the US* and the agency does not use section 5107 authority. However, this firm would be eligible for an award from an agency using section 5107 authority.

Example 6: The firm is eligible for agencies using section 5107 authority because a majority of the stock is owned by multiple VCOCs, hedge funds, or private equity firms and none owns more than 50%.

Example 7: The firm is eligible for agencies using section 5107 authority because, while the other small business "SB1" has the largest share, the firm is more than 50% owned by more than one VCOC, hedge fund, or private equity firm and none has more than 50% ownership.

Example 8: The firm is not eligible for the regular program. It is also not eligible for agencies using section 5107 authority because, although it is more than 50% owned by VCOCs, hedge funds, or private equity firms, one of these firms owns more than 50%.

Example 9: The firm is not eligible for the regular program because it is not majority owned by citizens of or permanent resident aliens in the US or other small businesses owned by citizens of or permanent resident aliens in the US, and it is not eligible for agencies using section 5107 authority because it is not majority owned by multiple VCOCs, hedge funds, or private equity firms.

Although the spirit of the SBA SBIR/STTR Program across the 12 participating Federal agencies is to assist in the development, infusion and commercialization of Innovative American technologies, there is room to establish partnerships, such as through subcontracts, within the rules, with international entities who bring to the table novel and unique abilities and ideas. Because of the original intent of the SBIR Program to focus on American businesses, it is unknown how much thought has been given to the other "49%" after the "51%" American owned requirement has been met and perhaps further research should be conducted by patent lawyers, to firmly lay out the eligibility factors from the international participants point of view. This information could then be added to the various SBIR/STTR governing documents. International partnering with a successful US owned SBIR award recipient after the completion of a Phase 2 and any follow-on bridge options may also be a way to continue to develop technology seeded with SBIR/STTR funding.

A venue that may be of interest and benefit to international companies wishing to collaborate with American Small Businesses, is that of the National SBIR STTR Conference held in Baltimore, MD (see https://www.sbir.gov/events for more info on this conference as well as others). SBIR representatives from all 12 SBIR participating Federal Agencies hold private meetings with the public as do many large prime companies looking to infuse SBIR technology.

VIII. Conclusion

Success have been large and small in scale. They have been complex systems and amazing firsts. They have expanded our knowledge and technical expertise, and some have been integral to the safety of crewmembers. NASA needs to afford attention to the obstacles preventing these successes from becoming public. While NASA as a whole has encouraged international partnering over the past two decades, the SBIR program would be strengthened by allowing for more foreign partnership opportunities. Addressing these concerns is good for the continuing health of NASA SBIR.

Acknowledgments

The authors would like to thank the NASA SBIR Program Manager, Carlos Torrez; the NASA SBIR Deputy Program Manager, Luis Mederos; the NASA SBIR Technology Infusion Manager, Dr. Ryszard Pisarski; the NASA SBIR Program Executive, Robert Yang; and the NASA SBIR Deputy Executive, Dr. Joseph Grant. The authors would also like to recognize and thank Yolanda Marshall, JSC Strategic Partnerships Office Manager; Steven Gonzalez, JSC Strategic Partnerships Office Associate Manager; Charlene Gilbert, JSC Technology Transfer and Commercialization Office Manager; and Dr. Kumar Krishen, Senior Scientist, JSC Technology Transfer Office.

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[1]Small Business Innovation Research (SBIR) Program Policy Directive, February 24, 2014

[2]SBIR website (sbir.nasa.gov)

[3]SBIR/STTR Program Solicitation (November 12, 2015 – February 1, 2016)

[4] JPR 2200.2, Release of JSC Scientific and Technical Information to External Audiences

[5] Techshot poster sheet (techshot.com)

[6]Small Business Innovation Research (SBIR) Program Policy Directive 6.(4). Small Business Administration Office of Investment and Innovation.

[7]NIH website (sbir.nih.gov/faqs)

[8]Guide to SBIR/STTR Program Eligibility, January 2013. US Small Business Administration.